AD-A172 523 AN AUTOMATED PORTABLE NIGHT VISION TESTING SYSTEM(U) 1/1
ARMY RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MA
J L KOBRICK ET AL. JUN 86 USARIEM-M-51-86

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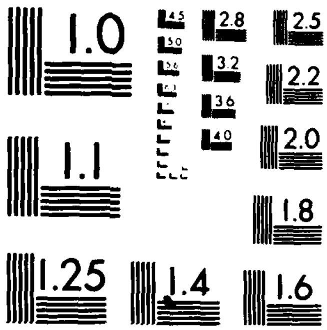

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER M51-86	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) An Automated Portable Night Vision Testing System	5. TYPE OF REPORT & PERIOD COVERED Manuscript
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John L. Kobrick, M.S., Ph.D., Calvin Witt, B.S., M.S. and Jose Miletti, B.S.	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Research Institute of Environmental Medicine, Natick, MA 01760-5007	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 3M161102BS10 64882101011
11. CONTROLLING OFFICE NAME AND ADDRESS Same as 9.	12. REPORT DATE June 1986
	13. NUMBER OF PAGES 12
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Night vision, Adaptometer, Dark adaptation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See reverse.

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This report describes a new testing system designed to assess night vision parameters of the military population in the field, and to quantify the effects of various environmental stress factors, such as extended exposure to high altitude, on the dark adaptation process. The instrument is based on an established procedure for dark adaptation measurement in which the subject continuously adjusts the threshold luminance of a recurrently flashing stimulus. The device described here represents a modernized version of the original technique, which features an automated testing procedure and provides for computerized data translation of the dark adaptation function. It also offers the advantages of rugged construction and field portability not available in clinical style instruments. This system has operated reliably under field conditions, and has generated valid dark adaptation functions on soldier test subjects at a high altitude field site.

Title:
An Automated Portable Night Vision Testing System

Authors:
John L. Kobrick, M.S, Ph.D., Calvin Witt, B.S., M.S.,
and Jose Miletti, B.S.

Laboratory of Origin:
U.S. Army Research Institute of Environmental Medicine
Natick, Massachusetts 01760

Address for Correspondence:
U.S. Army Research Institute of Environmental Medicine
Natick, Massachusetts 01760

Telephone:
(617) 651-4885

Running Head:
Night Vision Tester

Dr. John L. Kobrick is a Research Psychologist in the Health & Performance Division, US Army Research Institute of Environmental Medicine

Abstract

This report describes a new testing system designed to assess night vision parameters of the military population in the field, and to quantify the effects of various environmental stress factors, such as extended exposure to high altitude, on the dark adaptation process. The instrument is based on an established procedure for dark adaptation measurement in which the subject continuously adjusts the threshold luminance of a recurrently flashing stimulus. The device described here represents a modernized version of the original technique, which features an automated testing procedure and provides for computerized data translation of the dark adaptation function. It also offers the advantages of rugged construction and field portability not available in clinical style instruments. This system has operated reliably under field conditions, and has generated valid dark adaptation functions on soldier test subjects at a high altitude field site.

The instrument described here was designed for two purposes: (1) to establish a valid data base of night vision parameters for selected segments of the US Army military population both in the laboratory and during field operations; and, (2) to assess the effects of sustained hypoxia on night vision thresholds as reflected by the human dark adaptation function. Achievement of each of these objectives necessitated a night vision testing device which was rugged, reliable and simple to operate. Because of a specific requirement to study dark adaptation during prolonged exposure to moderately severe hypoxia, this instrument was designed to operate within the limited space available at a field laboratory of the US Army Research Institute of Environmental Medicine on the summit of Pikes Peak, CO (4300 m elevation), where the exposure conditions of interest could be achieved. Because of the usage demands on this unique facility, the available space is usually occupied by a number of test activities being conducted concurrently. Therefore, it was essential that the apparatus be as compact and portable as possible. In addition, night vision tests could only be performed in this situation if the subject and testing equipment could be isolated and made light-proof from the surrounding laboratory area.

The night vision tester (adaptometer) which was developed for use in this specialized situation, therefore, is uniquely self-contained, and can be operated within a normally illuminated room independent of ongoing activities. Unlike currently available clinical adaptometers which characteristically tend to be cumbersome and rather fragile, this system is designed for sturdiness and compactness. Also, it can easily be disassembled

for shipping, and re-assembled in a few minutes. The system has the additional advantage of being virtually automatic, since the test procedure follows a fixed sequence and utilizes a test stimulus which is directly and continuously controlled by the subject.

The basic design of this instrument is a modification of an adaptometer originated by Craik and reported by Matthews and Luczak (1). The original design was later modified and developed further for the US Navy by McLaughlin (2). In this technique, the variable intensity of a recurrently flashing stimulus light is continuously adjusted by the subject to approximate his own luminance detection threshold. (Another adaptometer based on this procedure, but of a somewhat different design, is still available on special order from the Marietta Apparatus Company, Marietta, OH.) In the instrument described here, the derived threshold luminance data expressed in log foot-lamberts are plotted versus an advancing time base to provide a conventional dark adaptation function.

Materials and Methods

The basic testing instrumentation consists of an optical bench on which are mounted a light source and the requisite optical components to generate the test stimulus. A schematic diagram of this system is shown in Figure 1, and is described in detail below.

Figure 1 about here

When assembled for use, the entire testing instrumentation is enclosed within a portable rigid light-tight housing. A fabric hood is then attached to one end of the erected housing so as to enclose the subject along with the test instrumentation within a light-tight envelope. The housing itself is hinged along the mid-line of its top and bottom surfaces to allow it to be collapsed into a flat compact package for shipping. The instrumentation system can also be disassembled and then shipped as a separate package of components.

The testing procedure begins by the subject entering the hood through an opening at its bottom; a drawstring installed in the edge seam of the opening is then tightened snugly around his waist. This enclosure design provides a comfortable and totally dark testing environment which is independent of the external ambient illumination. A small light-proof silent electric ventilation fan is mounted within the housing, and provides both an air supply to the subject and a means of dispelling heat. It should be noted that when the instrument was used at high altitude, the ventilation fan also served to insure that the prevailing hypoxic atmosphere was effectively transferred into the testing enclosure.

Inside the housing, a hemispheric surface painted flat white (Ganzfeld) (A) is positioned overhead and frontal to the subject's view in the seated position. This surface is illuminated indirectly by a 60-watt tungsten filament incandescent bulb mounted at its lower edge in a shielded receptacle. This device is used to pre-adapt the subject to a photopic threshold level prior to testing. When seated comfortably, the subject leans slightly back and orients his gaze upward at the illuminated Ganzfeld for

approximately five minutes. Thereupon, the Ganzfeld is extinguished, and the subject leans slightly forward into a chin-head rest (B), which is mounted at one end of a 36-inch optical bench so that the line of sight falls along its longitudinal axis.

The test stimulus is generated by a 40-watt incandescent tungsten filament light source contained in a lamp housing mounted at the other end of the optical bench. The housing contains a 1-inch circular aperture fitted with a milk-glass diffuser (C), with the aperture facing the subject. A scatter-eliminating light tube with a flat black inside surface (D) joins the light source aperture to a variable-aperture iris diaphragm (E) used to establish the size of the stimulus. The resulting stimulus then is intercepted by a sector disk rotating at 15 rpm, and containing a 22.5 degree angular gap (F). This arrangement produces a flash stimulus of 0.25 second duration occurring at a rate of 15 flashes per minute (one flash every four seconds), which is sufficiently intermittent and brief to have no effect on the natural course of the dark adaptation process. The stimulus is imaged then along the optic axis in sequence through: a Wratten neutral density filter stage used to adjust the range of the stimulus luminance (G); an accessory filter stage to allow insertion of chromatic filters when desired (H); a pair of circular counter-rotating matched neutral density wedges (Kodak No.96) mounted in a Gerbrands gear-drive optical wedge holder (Model G1310) (I); and, a 2" x 2" fused-glass diffusion plate (J) for imaging the emergent visual stimulus. A 1/8" circular red light (K) is mounted on a horizontal slide-wire placed perpendicular to the optic axis and 1" above the

imaged stimulus. This light assists the subject in maintaining fixation of the stimulus without altering the dark adaptation threshold. It can be adjusted easily for desired obliquity to the stimulus by moving it along the slide-wire to the desired position.

The gear drive of the wedge holder is directly connected by a straight shaft to a control knob (3 inches diameter) mounted convenient to the subject's right hand position (L). A clockwise rotation of the control knob decreases the luminance of the test stimulus by increasing the density of the wedges; conversely, a counter-clockwise rotation increases the stimulus luminance.

This overall arrangement produces a recurring intermittent flash stimulus which the subject can continue to increase or diminish in luminance by appropriate manipulation of the control knob to approximate the momentary luminance level of his dark adaptation threshold.

An optical incremental shaft encoder system with zero reference option (BEI Electronics; Model 260: 1000 counts per turn) is coupled by direct gearing to the output shaft of the wedge holder to provide digital quantitative encoding of the equivalent optical density of the wedges throughout their 360-degree rotation. The encoder interfaces through a voltage dividing circuit with the input terminals for the ordinate (Y) axis of an analog X-Y graphic recorder (0-20 volts DC, maximum excursion; Hewlett-Packard Model 7004B, or equal). The Y-axis of the recorder was calibrated empirically to represent the occlusion range of the optical wedges. This was done by measuring the virtual luminance of the visual stimulus at a variety

of settings of the variable density wedges throughout their absolute rotation using a digital photometer (e.g., Spectra Model U1-B, with night filter option), and marking the associated positions assumed by the cursor of the recorder along its Y-axis to provide a scale of equivalent stimulus luminance in units of millilamberts (mL). The abscissa (X) axis of the recorder is driven by a plug-in time base module advancing the cursor pen at a constant rate of 0.57 inches per second, which spans approximately a 12-inch baseline sweep over the conventional 20-minute night vision testing period.

The shaft encoder system also outputs to a dial-reading display to provide additional direct verification of the optical wedge positions at all times, and also generates associated TTL-compatible logic for computer conversion of the derived dark adaption threshold functions.

In summary, the system described above generates a target stimulus flashing at a constant rate of occurrence, which the subject continues to adjust to the lowest detectable (threshold) value over the course of the test period (usually 20 minutes). The X-Y recorder plots the equivalent luminance values in millilambert units represented on the Y-axis of a graphic recorder, versus the continuously advancing time base plotted on the X-axis, resulting in a graphic representation of the conventional dark adaption function.

If desired, a violet filter (Corning No. 5113) can be inserted in the accessory filter slot to increase the brightness of the scotopic portion of the dark adaptation function and reduce variability of the threshold settings in the portion of the curve immediately following the rod-cone shift (original recommendation by McLaughlin (2)).

Complete construction plans, optics and wiring diagrams can be obtained by contacting the authors at the above address.

References

1. Matthews BCH, Luczak AK. F.P.R.C. 577. 1944; R.A.F. Physiological Laboratory, Farnborough, England.

2. McLaughlin SC Jr. An automatic-recording visual adaptometer. J. Opt. Soc. Amer. 1954; 44(4): 312-314.

Suggested Sources of Component Equipment

Ealing Corporation, 22 Pleasant St., South Natick, MA 01760; Tel. (617) 655-7000 (Lamp housing; iris diaphragm; filter stages; optical bench)

BEI Electronics, Inc., 1101 McAlmont St., Little Rock, AK 72203; Tel. (501) 372-7351 (Optical shaft encoder with zero offset; and associated digital readout. These components are recommended as replacements for an integrated shaft encoder system formerly manufactured by Astrosystems, Inc., Cambridge, MA, no longer in business.)

Hewlett-Packard Co., Inc., Consult regional offices (X-Y graphic recorder).

Ralph Gerbrands Company, 8 Beck Road, Arlington, MA 02174; Tel. (617) 648-6415 (Optical wedge holder)

Eastman Kodak Company, Rochester, NY, Consult local Kodak dealers (Rotary optical wedges)

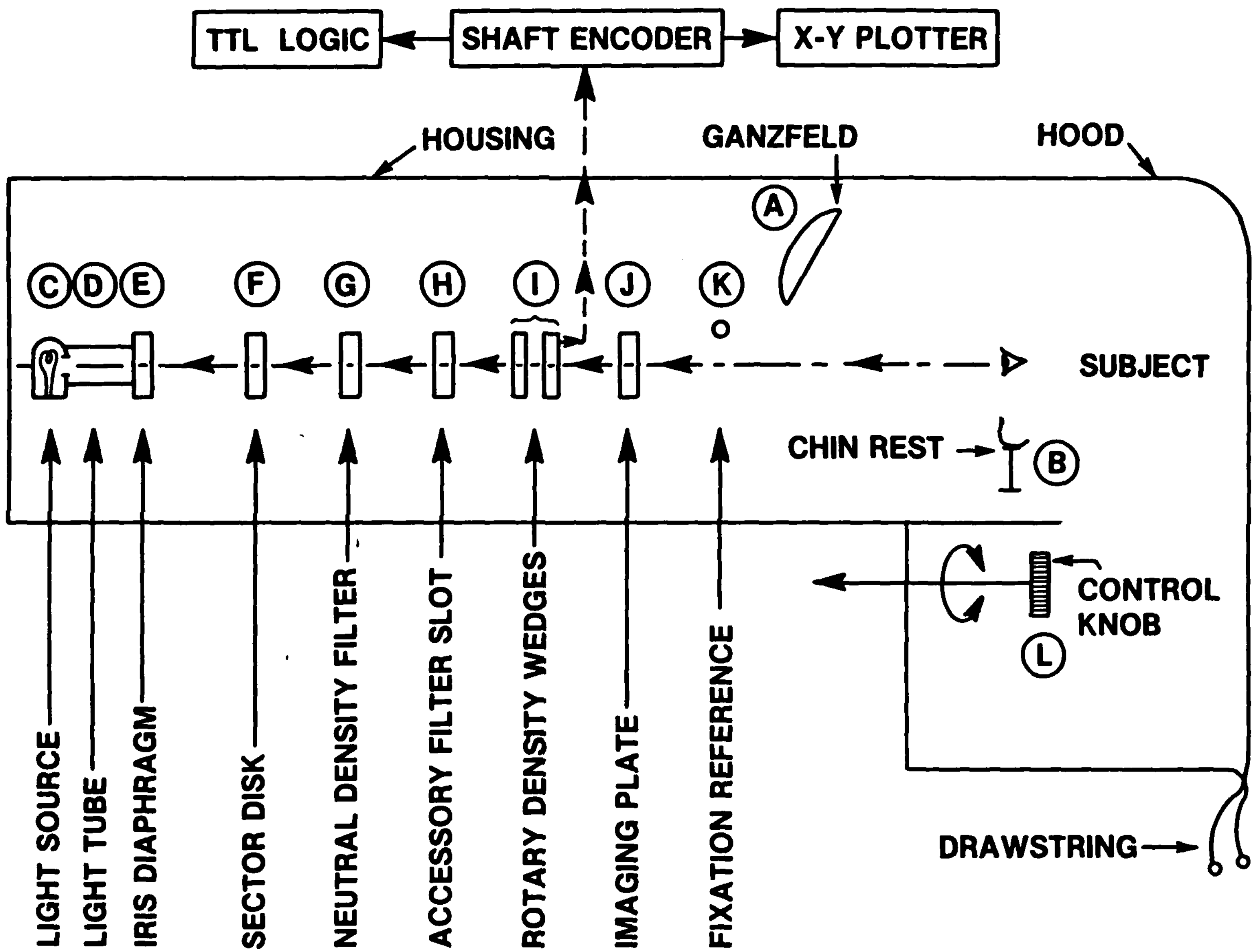
Disclaimer

1. The views, opinions and/or findings contained in this report are those of the author(s), and should not to be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation.

2. Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

Figure Captions

Figure 1. Schematic diagram of the apparatus



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HOOD
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I
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SUBJECT
CHIN REST
B
CONTROL KNOB
L
LIGHT SOURCE
LIGHT TUBE
IRIS DIAPHRAGM
SECTOR DISK
NEUTRAL DENSITY FILTER
ACCESSORY FILTER SLOT
ROTARY DENSITY WEDGES
IMAGING PLATE
FIXATION REFERENCE
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